

MAPPING ANCIENT IRRIGATION SYSTEMS IN SOUTHERN IRAQ USING HIGH-RESOLUTION SATELLITE IMAGERY

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Scientific Goal

Satellite remote sensing data are increasingly being used to identify and record archaeological sites and traditional landscapes. Given the wealth of high-resolution imagery that is now available, from declassified historical imagery to commercial multispectral data, it is possible to analyse how these locations have evolved.

The main goal of this work is to map ancient water management features in archaeological landscapes of southern Iraq to generate a robust satellite-based validation layer to test the novel artificial intelligence and deep learning methods that are being developed within the Dragon-6 project **STAI4CH**: *Spatio-Temporal AI-based EO data mining to assess anthropogenic impacts and sustainability measures on Cultural Heritage along ancient and modern waterways*.

Area of Interest

The work focuses on the waterscapes of the UNESCO World heritage site of the *Ahwar of southern Iraq: refuge of biodiversity and the relict landscape of the Mesopotamian cities*, inscribed in the List since 2016, and also known as the Iraqi Marshlands. The site is made up:

- **3 archaeological sites**: the cities of Uruk and Ur, and the Tell Eridu site, which form part of the remains of the Sumerian cities and settlements that developed in southern Mesopotamia between the 4th and 3rd millennium BCE in the marshy delta of the Tigris and Euphrates rivers
- **4 wetland marshlands**: one of the world’s largest inland delta systems, in an extremely hot and arid environment, including Huwaizah, East and West Hammar and Central Marshes

This study focuses on the development of irrigation from ancient times to the present day in an area of southern Iraq bounded between the western desert and the modern course of the Euphrates, and the remaining areas of the marshes to the south. A particular emphasis is put on the spring of Ayn Sayed and nearby irrigation systems, including features pre-dating the 1st millennium AD, and gravity-flow canal systems originating in the Sasanian (224-651) AD period drawing from both river and spring abstraction points. Some of these systems were in use until very recently and a few areas still intermittently are cultivated using them.



Interpretation & Conclusions

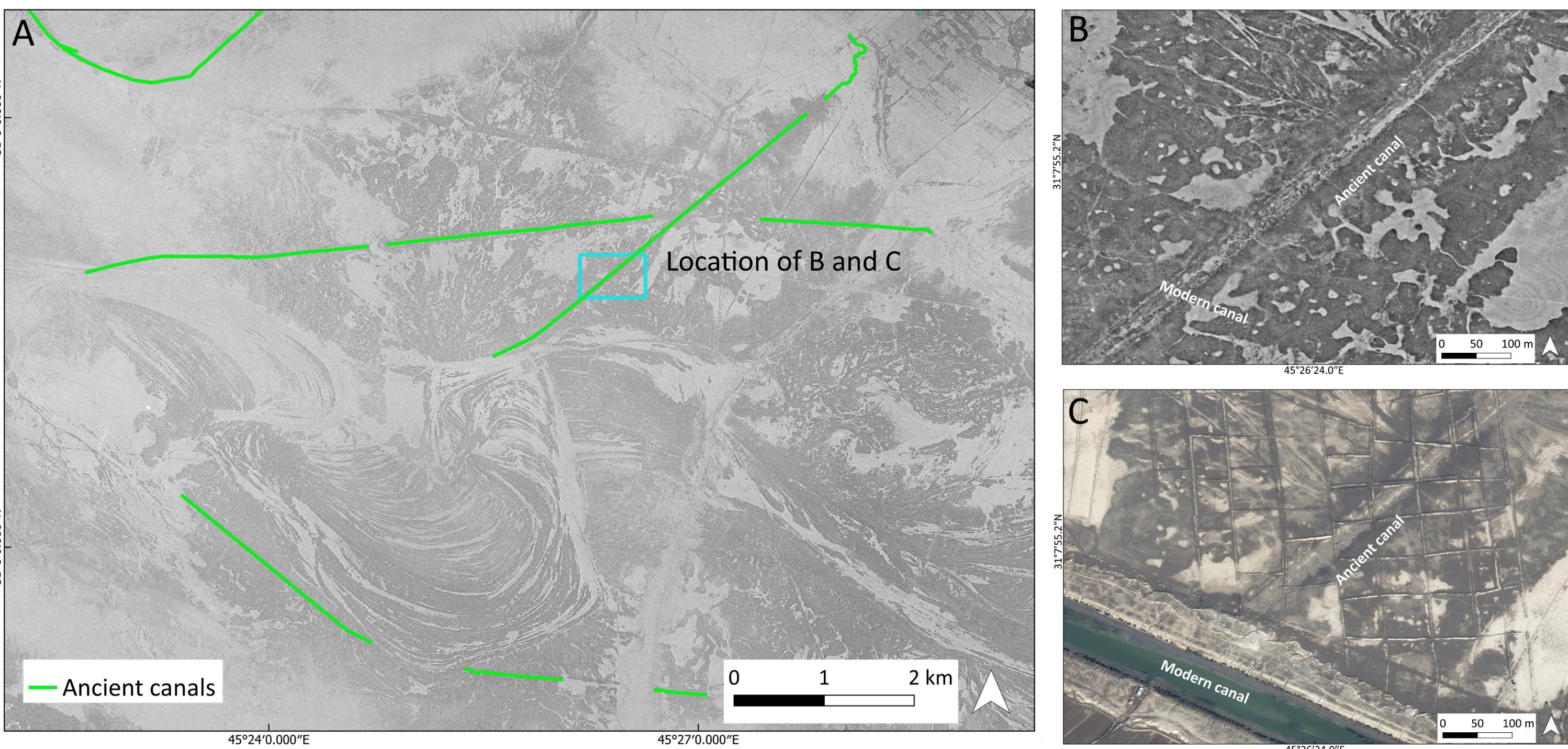
Canals within the Ayn Sayed region abstract water from three key sources: the modern Euphrates, a relict course of the ancient Euphrates, and the Ayn Sayed spring. Two irrigation phases were identified:

- **Ancient (3rd –1st millennium BC)**: canals connected to a now-dry Euphrates course
- **Historical to 20th century**: systems drawing from Ayn Sayed spring and the modern Euphrates

Field systems showed traditional “herringbone” layouts, with interlinked canals indicating adaptation, reuse, and dual-source irrigation.

The complex irrigation network reflects cycles of construction, reuse, and abandonment across periods. Canals often served multiple field systems and adapted to changing hydrological conditions. The results align with oral histories from local farmers and support the understanding that dual-source irrigation has long been a sustainable strategy in this landscape.

Ayn Sayed’s irrigation system has roots in antiquity and continues to support agriculture today. Satellite imagery reveals not only its historical depth but also its adaptability. As environmental threats increase, understanding these traditional systems could inform future water management and resilience strategies.



A-B) KH-9 image 22/02/1981; C) Pléiades Neo imagery PNEO image 01/12/2022 ©Airbus DS (2022).

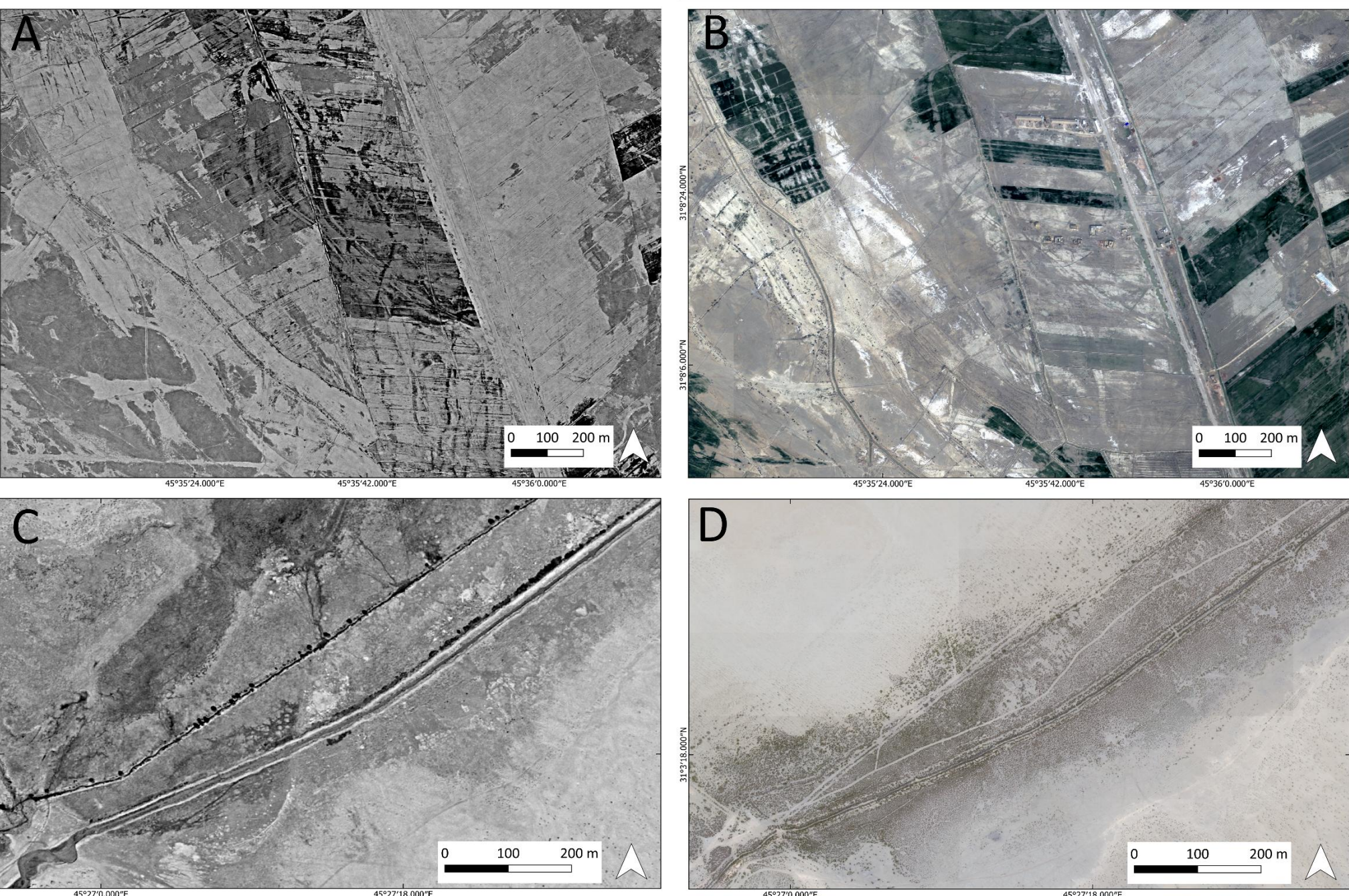
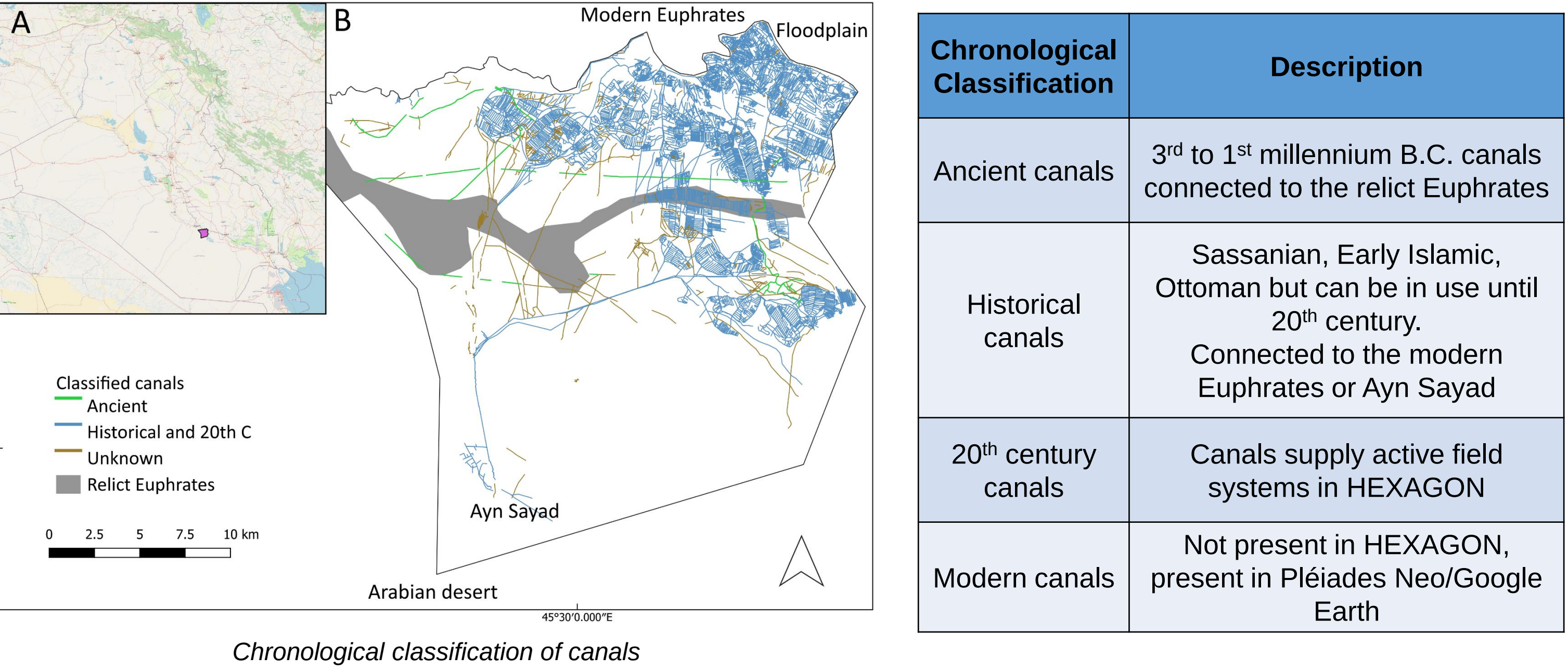


EO Data & Processing

- High-resolution satellite data were used to digitise canals and classify them chronologically:
- Declassified US Cold War Era **HEXAGON** (also known as KeyHole-9, KH-9) (1974-1981) images enabled the recording of the layout of the irrigation systems prior to more recent intensification of agriculture. The data were orthorectified using ERDAS with RMSEs of 1.4-2.9 m. With a resolution of up to 0.6 m, fine details of features could be mapped.
 - **Pléiades Neo** was purchased from Airbus DS and processed in ArcGIS Pro. The 6 bands were stacked and pansharpened to the 0.3 m resolution of the panchromatic band, using the Gram-Schmidt algorithm to blend higher and lower bands whilst keeping the spectral properties intact. The data enabled the identification of the land use activities which are involved, for example the production of bricks.
 - **Landsat** (from 1985) and **Sentinel-2** (from 2018) multispectral imagery obtained via Google Earth Engine allowed the impact of the recent changes to be mapped and measured
 - **Google Earth** sequences of VHR imagery, and the **SRTM** digital surface model, were used to support image interpretation and further analysis

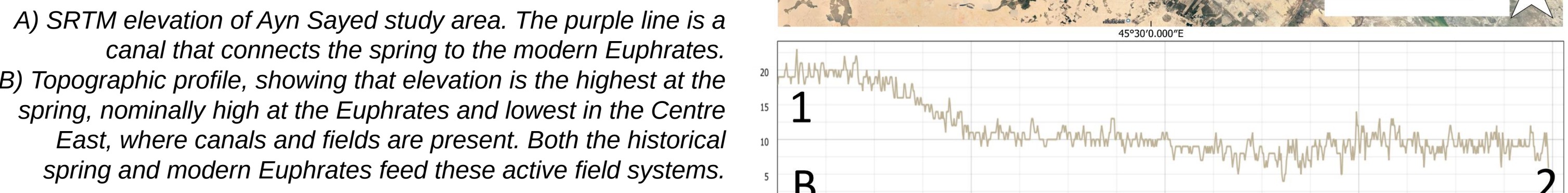
Analysis & Classification Key

A standardised image interpretation approach and a classification key based on imagery characteristics and abstraction points were developed to separate the systems into ancient canals, historical canals, 20th century canals, and modern canals; the mapping of these canals provides a proxy for field system locations.



Herringbone canals are traditional field systems associated with traditional, historical field systems. The Pléiades Neo data were used to show that these systems are still active in the 21st century.

Elevation analysis using SRTM data demonstrates that canals follow natural gradient declines from both sources, confirming dual-direction irrigation into the same field systems. This supports the interpretation of a complex, multi-period irrigation network sustained by diverse and resilient water sources over millennia.



These canal systems are now at risk due to climate change and modern development. While traditional canals may offer a sustainable alternative to modern pumping methods in the face of climate change, socio-environmental issues pose a threat to them.

Acknowledgements

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